



6th Meeting of the HL-LHC Technical Committee

Participants: G.Arduini, A.Ballarino, V.Baglin, A.Bertarelli, O.Bruning (chair), H.Burkhardt, R.Calaga, C.C. Gonzalez, P.Fessia, C. Magnier, V.Montabonnet, L.Rossi, Andrzej Siemko, Ezio Todesco, M.Zerlauth

Excused: H.Burkhardt, D. Duarte Ramos, W.Hoefle, M.Lamont, Stefano Redaelli, E.Todesco, J.Uythoven, R.Vennes

The slides of all presentations can be found on the website and Indico pages of the PLC:

HL-LHC PLC/TC homepage: <https://espace.cern.ch/HiLumi/PLC/default.aspx>

Indico link: <https://indico.cern.ch/event/323501/>

Conceptual vacuum layout and integration in high-luminosity insertions (V.Baglin - [slides](#))

V.Baglin recalled the main objective of the Vacuum Layout for the HL LHC era, namely to ensure the vacuum performance in terms of stability and (low) background to the experiments in view of the twice higher beam current and the resulting issue with ion desorption. For the latter, experiments featuring complex and dedicated vacuum chambers (Be, Al and stainless steel) need to define the allowable background still.

It should be noted that initial computations need to be re-iterated once the layout is finally frozen.

V.Baglin showed a plot indicating the contribution from different components (CO, H₂, CH₄) to the overall molecule density in the LSS right of IR1. Pressure bumps during operation occur mainly due to the missing perforation of the beam screen to the cold mass and/or at cold-warm transitions. In addition, in the interconnection regions the pumping only happens from the extremities.

R.Calaga enquired about the importance/contribution of nitrogen in the given scale. V.Baglin replied that without beam the static pressure is much lower still, in presence of beam the 4 quoted gas components are predominant.

Layout generalities that will be taken into account for the HL-LHC design are as follows:

- There will be a sectorisation at each cold-warm transition to have the lowest unbaked length at room temperature.
- Cryogenic system with perforated beam screen everywhere
- The room temperature system will be entirely NEG coated; the minimum bake-out temperature is defined as 250 degrees to remove water. For strongly bound molecules one needs to go to at least 300 (measures valid for metallic surfaces)
- Integration studies will have to take into account as well mobile system (bake-out, pumping groups) and installation/de-installation of components.

A.Bertarelli enquired what minimum bake-out temperature the equipment systems have to account for, as the collimators are currently designed for bake-out at 300 degrees Celcius. V.Baglin confirmed that higher temperatures are obviously even better but that 250 degrees remains the minimum requirement.

O.Bruning commented that in operation the temperature of these elements will never get that high – why do we need to bake at such high temperatures? V.Baglin replied that the ion bombardment during beam operation is very effective to detach these molecules; hence a good prior cleaning is required. O.Bruning commented that in such case any surface exposed to the beam should be baked to 300 degrees.

P.Fessia proposed that these limits are added to the HL-PLC pages as a reference design value. .

One pumping port every ~ 20m is judged sufficient by the vacuum team. Before bake-out levels of 10E-8 to 10E-7 mbar can be expected, which improves to 10E-11 mbar after bake-out. For LHC, ion pumps are present every 28m (needs to be reviewed for HL-LHC).

In the following the different vacuum regions of a high-luminosity LSS were reviewed in detail.

Experiments feature very complex and dedicated vacuum chambers made out of Be, Al (ATLAS) and stainless steel (CMS), all of which are NEG coated.

The thickness of flanges is minimised using helicoflex gaskets, the chambers are maintained in position by an adapted/dedicated supporting system, and dedicated remote tooling needs to be available for the TAS (an incident of the RF bridge in January 2012 was highlighted).

H.Burkhardt commented that this incident came as bad surprise, as the RF bridge is a very important component. For the vacuum team this is obviously a very delicate area for interventions due to the high levels of radiation at the TAS.

P.Fessia commented that first RP results for the TAS-Q1 interconnect are known today, confirming that one probably can only access for some 10 minutes in this region.

L.Rossi asked whether we still need a remote alignment system. We know today that the cavern is much more stable than large parts of the tunnel regions. Only the transversal movement is not good (longitudinal is OK for contraction compensation).

The element which is the most difficult to integrate here is the alignment system which is consuming space and blocks the opening of interconnections. O.Bruning confirmed that nevertheless that the present alignment accuracy is still required for HL-LHC.

The inner triplet region already features perforated and shielded a-C coated beam screens that are actively cooled. Still the Q3-D1 region contains the longest unbaked length in the whole LHC of $\sim 1.3\text{m}$, which always was a weak area. To mitigate this as much as possible the sector valve has been moved for the HL-LHC design to D1.

LLRB did never exist for the LHC. The region in question is already sectorised. Whatever the final solution, the materials used must survive the previously defined bake-out values.

TAN-D2 region: Only a very short distance is available to accommodate all needed components (7.43m), which was not properly done during LHC construction and hence obstructs the movement of the TCT in the '5th axis' (allowing to move by $\pm 10\text{mm}$ to use a fresh surface of the TCT after e.g. damage following an asynchronous beam dump event). The collimator envelope needs to be re-designed taking into account the needed mobile vacuum equipment.

P.Fessia commented that in the current HL layout version the TCTs are only integrated using the active jaw length, as the mechanical integration would not fit if using the overall length – this has to be redesigned or another solution to be found.

O.Bruning commented that WP2 is already looking into options to make the TAN moveable (not remotely but adapt to flat-beams, round beams...)

The D2, Q4, Q5, Q6 region will reuse the existing sector-valve assembly, and should feature the same a-C coated beam screens (cooled to 5-20K) as the inner triplet region (cold-mass at 1.9K).

P.Fessia enquired whether we absolutely need fully amorphous carbon coating on all these magnets as this will need to be added to the work on the magnets while on the surface. V.Baglin confirmed that this would indeed be very beneficial.

L.Rossi commented that the validation of a-C coating at cryo conditions would soon be done in COLDEX. He asked why we do not coat the bellows, which should be possible? G.Arduini replied that they are all equipped with RF contacts, so one would need to coat the RF fingers rather than the bellows?

R.Calaga commented that the bellows have to sustain a lot of cyclic movements, and that hence the a-C would probably not stick for a long time.

In the Crab cavity region the Q4 and Q5 are already sectorised, as well are collimators/absorbers in that region. Also the four crab-cavity modules will be sectorised with a space reserved for the collimation option. V.Baglin pointed out that it is important to foresee a beam screen/shadowing of the 2nd non-accelerated beam in the crab-cavity in order not to outgas towards the cavities. A possibility is e.g. a butterfly vacuum chamber to pump at the surface not exposed to the beam.

The crab cavity vacuum valves inside the insulation vacuum are not inserted into the sector valve chain; hence between the two crab modules (per beam) there will be another sector valve to allow for potential removal of a single module.

The space reserved between the cryo-modules is foreseen for their interconnection (requiring two sector valves, hence there is no space available for other equipment).

Action: Need to study the impact of electron cloud and synchrotron radiation on crab modules.

R.Calaga commented that the expected SEY is around 1.1-1.2 (but points out as well the 80mm diameter and high fields which might increase the SEY). Another worry is the electron cloud activity in the aperture (transition Niobium and stainless steel). Also external fields need to be kept in mind (if e.g. using solenoids) as especially during the cool-down the cavities are sensitive to some few 10s of μ T only; once cold they are much less sensitive (200mT).

G.Arduini added that the first type test in SPS would bring the first realistic estimates on this issue, as the current simulation codes are not yet implementing crab-cavities.

Action: O.Bruning recommended testing this already in the SPS and SM18 (which would come almost for free as there big magnets are located in the vicinity.)

V.Baglin concluded that the conceptual layout is well advanced, and the objective is to achieve vacuum performances compatible with HL-LHC (1.12 A per beam, $2.2 \cdot 10^{11}$ ppb, 2748 b), resulting in 2.24 A in the IP instead of 1.16 A for LHC which is well above the vacuum stability design margin. Efforts will continue to review/redesign and develop along the LSS the remote tooling and re-use wherever possible vacuum equipment from the LHC.

Discussion:

O.Bruning commented that the DS cryo-collimators seem not yet considered. V.Baglin confirmed that the current presentation only considers the new HL-LHC Layout presented recently by P.Fessia, which does not yet extend to the dispersion suppressor regions.

O.Bruning asked whether the fact of having two different DFBs does not affect the vacuum. P.Fesia replied that only a very short length is at cold and on the beam line. He added that the same VAB will be used as currently installed for the LHC. V.Baglin confirmed that this will mainly be an integration issue and not one for vacuum.

H.Burkhardt reminded that the background issue was mostly present in IR2, mostly originating from the TDI. Work is already ongoing during LS1 on the TDI, Y.Uythoven is currently writing the conceptual specification for the new generation of TDI, due for installation during LS2.

It has to be kept in mind that IP8 is also becoming a 'half' Hi-Lumi region (with $2E33$ of peak luminosity or maybe even more)

G.Arduini commented on the difficulty for vacuum in the crab-cavities. Indeed no beam screens can be installed due to an issue of aperture, hence two anti-chambers are currently foreseen in order to allow for molecules to move there and be pumped.

AOB - None